ETH Zürich
Chair of Software Engineering

Einführung in die Programmierung
Introduction to Programming

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Exercise Session 6

Today

- Conditional
- Loop
- Linked list

Inside the routine body

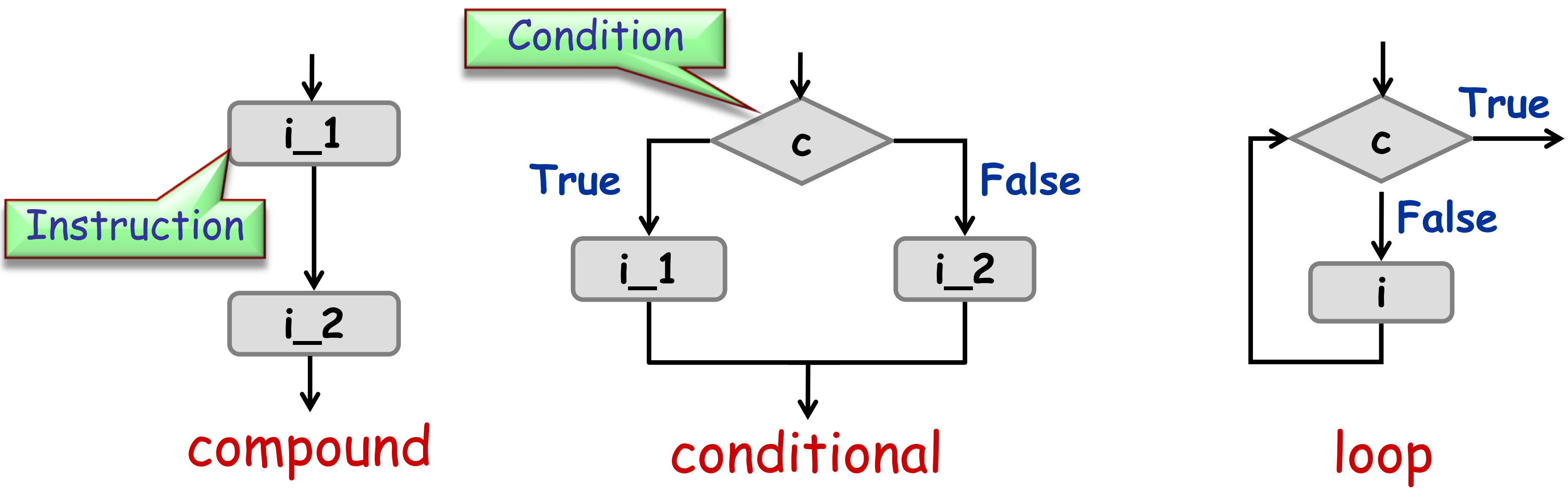
- The body of each routine consists of instructions (command calls, creations, assignments, etc.)
- In the programs you've seen so far they were always executed in the order they were written

```
create passenger.make_with_route (Route3, 1.5)
passenger.go
passenger. set_reiterate (True)
Paris.put_passenger (passenger)
create tram.make_with_line (Line1)
tram.start
Paris.put_tram (tram)
```

- Programming languages have structures that allow you to change the order of execution

Structured programming

- If the order of execution could be changed arbitrarily, it would be hard to understand programs
- In structured programming instructions can be combined only in three ways:



- Each of these blocks has a single entrance and exit and is itself an instruction

Conditional

- Basic syntax:

```
if c then          Condition
    i_1            Instruction
else
    i_2            Instruction
end
```

- *c* is a boolean expression (e.g., entity, query call of type *BOOLEAN*)
- **else**-part is optional:

```
if c then
    i_1
end
```

Compilation error? Runtime error? (1)

Hands-On

```
f (x, y: INTEGER): INTEGER
        do
                if (x // y) then
                        1
                else
                        0
                end
        end
```

Compilation error:

integer expression instead of boolean

Compilation error:

expression instead of instruction

Compilation error? Runtime error? (2)

Hands-On

```
f (x, y: INTEGER): INTEGER
    do
        if (False) then
            Result := x // y
        end
        if (x /= 0) then
            Result := y // x
        end
    end
```

Everything is OK

(during both compilation and runtime)

Calculating function's value

Hands-On

```
f (max: INTEGER; s: STRING): STRING
        do
                if s.is_equal ("Java") then
                        Result := "J**a"
                else
                        if s.count > max then
                                Result := "<an unreadable German word>"
                        end
                end
        end
```

Calculate the value of:

- *f* (3, "Java") → "J**a"
- *f* (20, "Immatrikulationsbestätigung") → "<an unreadable German word>"
- *f* (6, "Eiffel") → **Void**

What does this routine do?

Hands-On

```
abs (x: REAL): REAL
        do
            if (x >= 0) then
                Result := x
            else
                Result := -x
            end
        end
```

Write a routine...

Hands-On

- ... that computes the maximum of two integers:

  max (a, b: INTEGER): INTEGER

- ... that increases time by one second inside class *TIME*:

```
class TIME
    hour, minute, second: INTEGER

    second_forth
        do ... end
    ...
end
```

Comb-like conditional

If there are more than two alternatives, you can use the syntax:

Condition

Instruction

```
if c1 then
        i_1
elseif c2 then
        i_2
...
elseif c_n then
        i_n
else
        i_e
end
```

instead of:

```
if c_1 then
   i_1
else
   if c_2 then
      i_2
   else
      ...
      if c_n then
            i_n
      else
            i_e
      end
      ...
   end
end
```

Multiple choice

If all the conditions have a specific structure, you can use the syntax:

```
inspect expression
when const_1 then
        i_1
when const_2 then
        i_2
...
when const_n1 .. const_n2 then
        i_n
else
        i_e
end
```

Integer or character expression

Integer or character constant

Instruction

Interval

Lost in conditions

Hands-On

Rewrite the following multiple choice:

- using a comb-like conditional
- using nested conditionals

```
inspect user_choice
when 0 then
        print ("Here is your hamburger")
when 1 then
        print ("Here is your Coke")
else
        print ("Sorry, not on the menu today!")
end
```

Lost in conditions: solution

```
if user_choice = 0 then
        print ("Here is your hamburger")
elseif user_choice = 1 then
        print ("Here is your Coke")
else
        print ("Sorry, not on the menu today!")
end
```

```
if user_choice = 0 then
        print ("Here is your hamburger")
else
        if user_choice = 1 then
                print ("Here is your Coke")
        else
                print ("Sorry, not on the menu today!")
        end
end
```

Loop

Syntax:

```
from
        initialization          Instruction
invariant                       Optional
        inv                     Boolean expression
until
        exit_condition          Boolean expression
loop
        body                    Instruction
variant
        var                     Integer expression
end
```

Simple loop (1)

Hands-On

How many times will the body of the following loop be executed?

```
i: INTEGER
...
from
        i := 1
until
        i > 10
loop
        print ("I will not say bad things about assistants")
        i := i + 1
end
```

In Eiffel we usually start counting from 1

10

Simple loop (2)

Hands-On

And what about this one?

```
i: INTEGER
...
from
        i := 10
until
        i < 1
loop
        print ("I will not say bad things about assistants")
end
```

∞

Caution!

Loops can be infinite!

What does this function do?

Hands-On

```
factorial (n: INTEGER): INTEGER is
        require
                n >= 0
        local
                i: INTEGER
        do
                from
                        i := 2
                        Result := 1
                until
                        i > n
                loop
                        Result := Result * i
                        i := i + 1
                end
        end
```

Invariant and variant

Loop invariant (do not mix with class invariant)

- holds after execution of **from** clause and after each execution of **loop** clause
- captures how the loop iteratively solves the problem: e.g. "to calculate the sum of all *n* elements in a list, on each iteration *i* (i = 1..n) the sum of first *i* elements is obtained"

Loop variant

- integer expression that is nonnegative after execution of **from** clause and after each execution of **loop** clause and strictly decreases with each iteration
- a loop with a correct variant can not be infinite (why?)

Invariant and variant

Hands-On

What are the invariant and variant of the "factorial" loop?

from

$i := 2$

Result := 1

invariant

Result = $factorial(i - 1)$

Result = 6 = 3!

until

$i > n$

loop

Result := **Result** * i

$i := i + 1$

variant

$n - i + 2$

end

Writing loops

Hands-On

Implement a function that calculates Fibonacci numbers, using a loop

```
fibonacci (n: INTEGER): INTEGER
            -- n-th Fibonacci number
      require
            n_non_negative: n >= 0
      ensure
            first_is_zero: n = 0 implies Result = 0
            second_is_one: n = 1 implies Result = 1
            other_correct: n > 1 implies Result =
                  fibonacci (n - 1) + fibonacci (n - 2)
      end
```

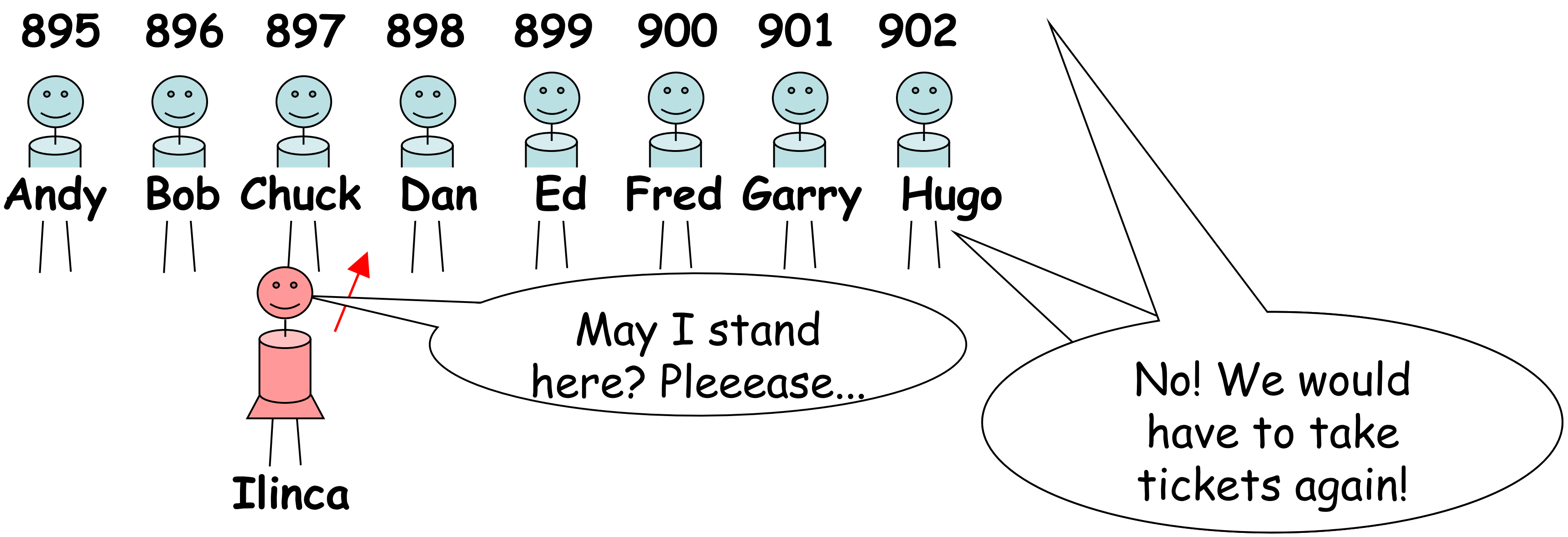
Writing loops (solution)

Hands-On

```
fibonacci (n: INTEGER): INTEGER
        local
                a, b, i: INTEGER
        do
                if n <= 1 then
                        Result := n
                else
                        from
                                a := fibonacci (0)
                                b := fibonacci (1)
                                i := 1
                        invariant
                                a = fibonacci (i - 1)
                                b = fibonacci (i )
                        until
                                i = n
                        loop
                                Result := a + b
                                a := b
                                b := Result
                                i := i + 1
                        variant
                                n - i
                        end
                end
        end
```

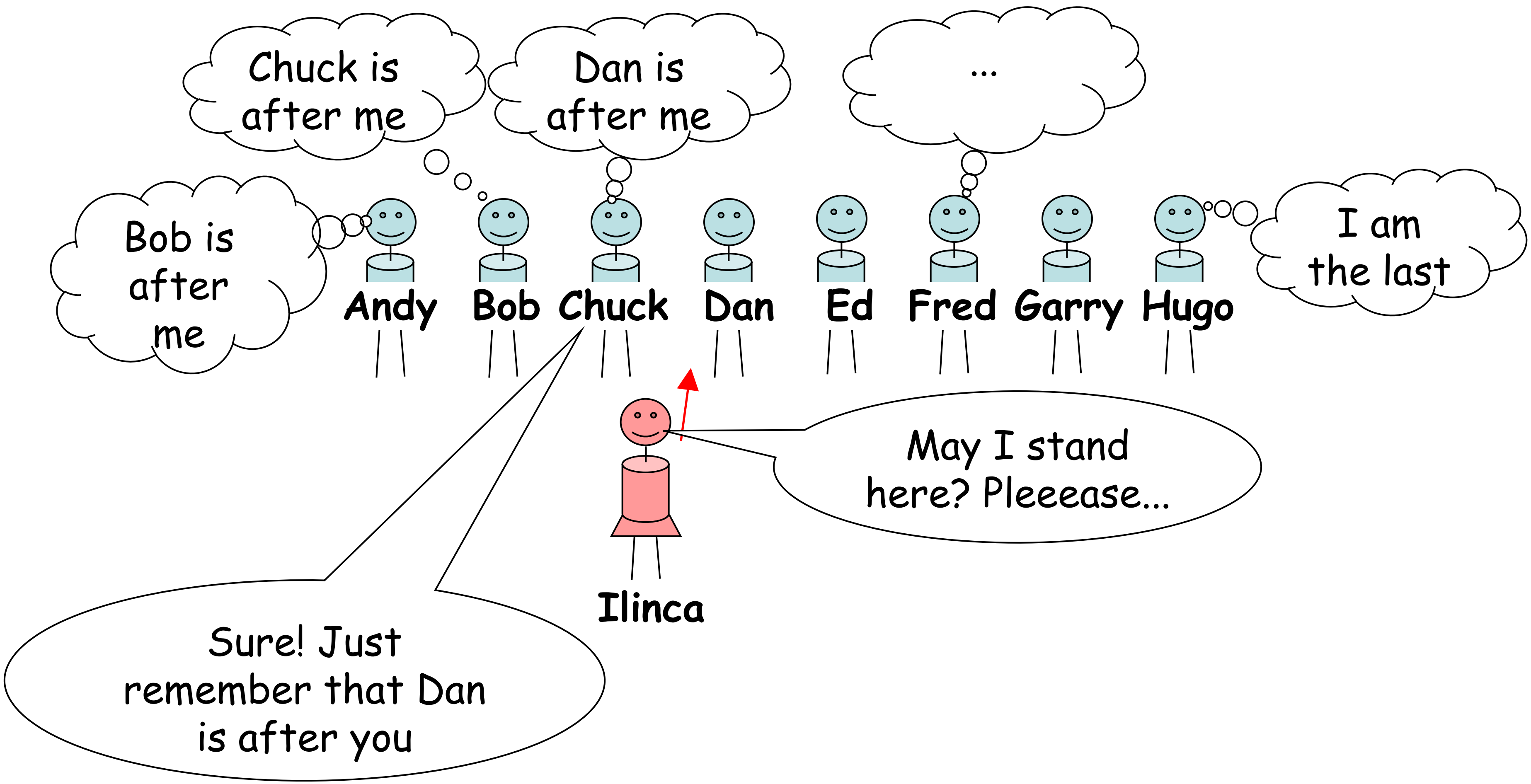
Two kinds of queues

Electronic queue (like in the post office)



Two kinds of queues

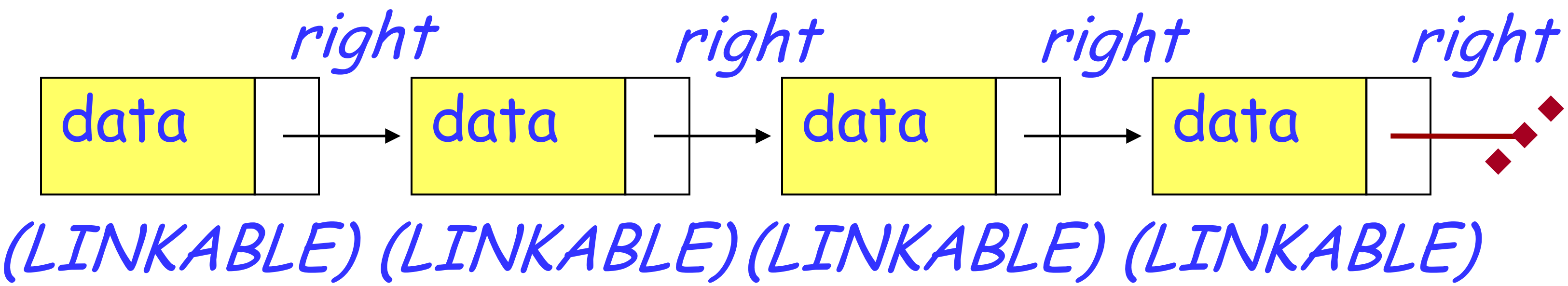
Live queue



LINKABLE

To make it possible to link infinitely many similar elements together, each element should contain a reference to the next element

```
class LINKABLE
        feature
                ...
                 right: LINKABLE
end
```



INT_LINKABLE

```
class INT_LINKABLE
create put
feature
        item: INTEGER

        put (i: INTEGER)
                do item := i end

        right: INT_LINKABLE

        put_right (other: INT_LINKABLE)
                do right := other end
end
```

INT_LINKED_LIST

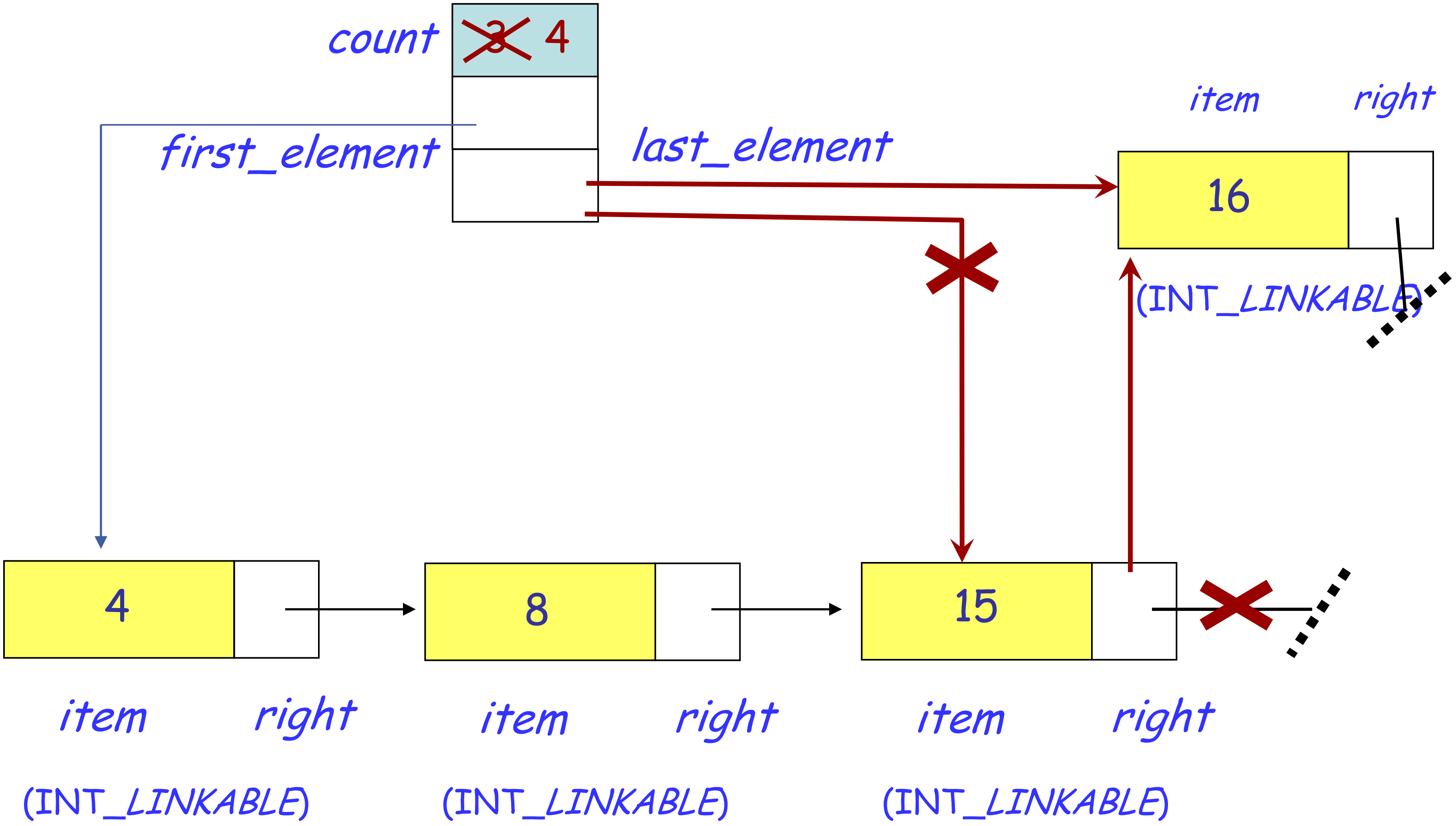
```
class INT_LINKED_LIST
feature
        first_element: INT_LINKABLE
                -- First cell of the list

        last_element: INT_LINKABLE
                -- Last cell of the list

        count: INTEGER
                -- Number of elements in the list

        ...
end
```

INT_LINKED_LIST : inserting at the end



INT_LINKED_LIST: inserting at the end

```
extend (v: INTEGER)
        -- Add v to end.
    local
        new: INT_LINKABLE
    do
        create new.put (v)
        if first_element = Void then
            first_element := new
        else
            last_element.put_right (new)
        end
        last_element := new
        count := count + 1
    end
```

INT_LINKED_LIST: search

```
has (v: INTEGER): BOOLEAN
            -- Does list contain v?
    local
            temp: INT_LINKABLE
    do
            from
                    temp := first_element
            until
                    (temp = Void) or Result
            loop
                    if temp.item = v then
                            Result := True
                    end
                    temp := temp.right
            end
    end
```

INT_LINKED_LIST

Hands-On

Write a routine that

- calculates the sum of all positive values in a list

sum_of_positive: *INTEGER*

do ... **end**

- inserts an element after the first occurrence of a given value and does nothing if the value is not found

insert_after (*i*, *j*: *INTEGER*)

do ... **end**

INT_LINKED_LIST: sum_of_positive

```
sum_of_positive: INTEGER
        -- Sum of positive elements
    local
        temp: INT_LINKABLE
    do
        from
            temp := first_element
        until
            temp = Void
        loop
            if temp.item > 0 then
                Result := Result + temp.item
            end
            temp := temp.right
        end
    end
```

INT_LINKED_LIST: insert_after

```
insert_after (i, j: INTEGER)
        -- Insert `j' after `i' if present
    local
        temp, new: INT_LINKABLE
    do
        from
            temp := first_element
        until
            temp = Void  or else  temp.item = i
        loop
            temp := temp.right
        end
        if  temp /= Void then
            create  new.put (j)
            new.put_right (temp.right)
            temp.put_right (new)
            count := count + 1
            if  temp = last_element  then
                last_element := new
            end
        end
    end
```